Pbar Annihilation in $Au + Au$ at AGS Energies

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A recent publication from E878 [1] reported antiproton yields in a limited kinematical region near $p_t = 0$, for $11\,GeV/c$ $Au + Au$ beams at the AGS. The data was compared to calculations performed with the cascades RQMD and ARC and certain conclusions were drawn based on this comparison. What was missing from this analysis was reference to the overwhelming role that would have been played by unbridled annihilation, and consequently to the surprising result that theory is at all close to measurement. This is apparent from Figure 1 where we have reproduced the most central cut from [1] but added some ARC calculations, unfortunately not included in the latter publication. First, we call attention to the large normalisation factor, ~ 30 integrating over all y and p_t, between antiproton yields for pure production (but with $\bar{p}$ rescattering) and that for production + unadulterated annihilation, i.e. without the screening introduced for $Si + Au$ [2].

From these data and the previous analysis [2], it is apparent that screening is essential. This modification in the $p\bar{p}$ interaction arose from an insistence on causality. The p and $\bar{p}$ should not annihilate before they touch, while the large free-space cross sections allow annihilation at separations in excess of $3\,fm$. In the medium, other particles will frequently interfere before any contact, thus generating the classical shielding. For Si+Au [2] we introduced a time delay τ_a calculated dynamically from the $N\bar{N}$ separation and relative velocity, permitting annihilation only after *complete* overlap. In Figure 1 we present Au+Au $\bar{p}$ yields for an annihliation probability taken proportional to the overlap volume (volume shielding), as well as the correct simulations from the old complete overlap [1].

The results in Figure 1 are reasonable, fortuitous to some extent considering the large annihilation factors, but built on a straightforward modeling. The $Au + Au$ $\bar{p}$ production rapidity shape is well described by ARC + screening and the magnitudes can even be approached with some quantitative understanding. We took $b < 5\,fm$ to closely approximate the trigger used in Ref. 1. The variance between "old" screening and new volume-overlap screening, some 35%, could be taken as an extreme limit for the theoretical uncertainty, but with the new, volume, screening designated as the the theoretical norm since annihilation can commence before complete overlap A prime reason for the relative stability of the modeling is the screening-induced reduction of the large free annihilation cross-section to something close to that related to the average separation in the nuclear environment. The cascade is a powerful tool for handling this three body process, and once some form of shielding is in place the calculated yields are stable.

Can one use antiparticles as a signal for unusual behaviour at these low energies? Probably not at a level one would like. We do not here, nor did we in earlier publications [2], claim a "good" quantitative understanding of low energy $\bar{p}$'s, but in fact have done much better than might have been expected. At the AGS Au beam momenta one may need measurements of $\sigma(pp \rightarrow \bar{p})$ rather than relying just on extrapolation from higher energies. A kinematically more comprehensive set of $\bar{p}$ data, perhaps from the AGS experiments E864 and E866, should allow one to exploit the successes of the modeling presented here.

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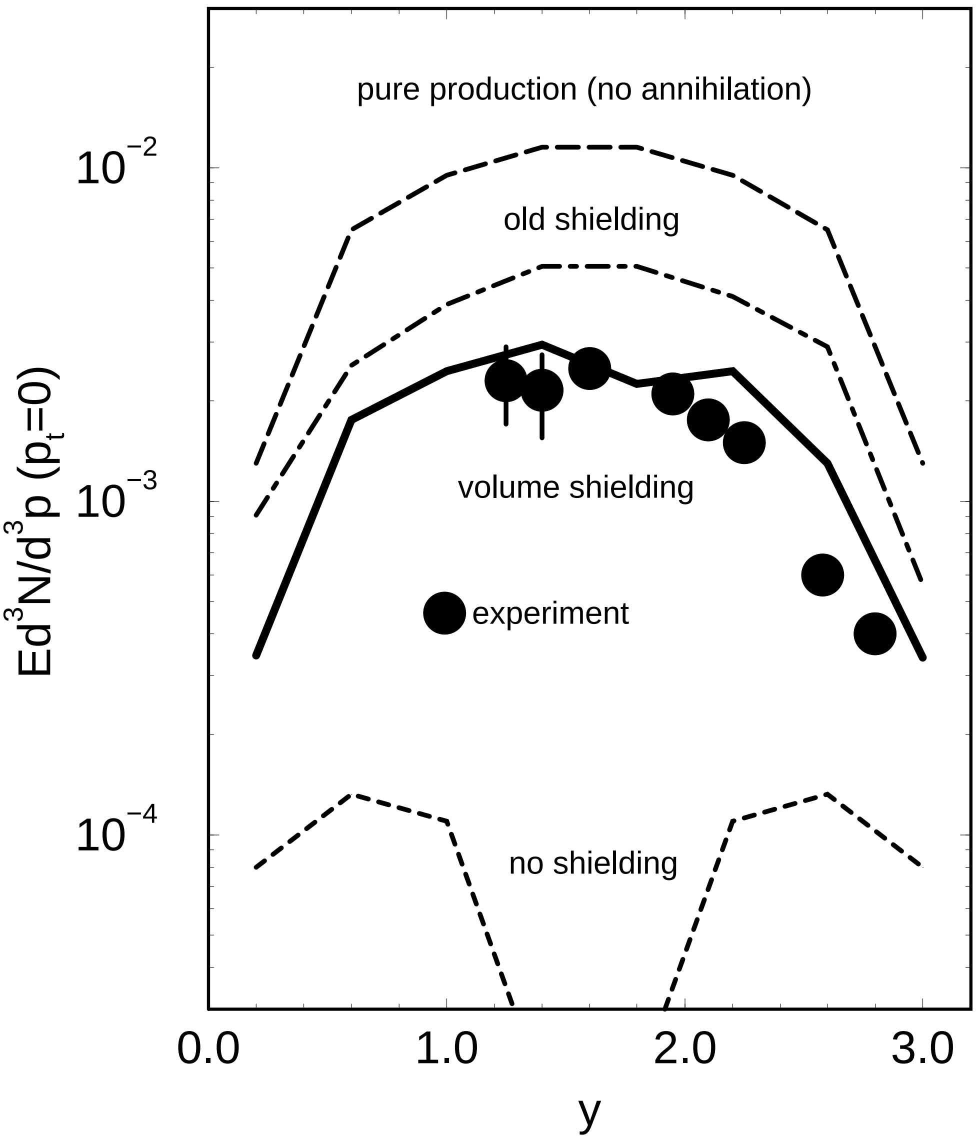

FIG. 1. Antiproton production for Au+Au at 11.0 GeV/c